CONTINUOUS FIBER CERAMIC COMPOSITES

Project Fact Sheet

INDUSTRIAL GAS TURBINE CFCC COMPONENTS

BENEFITS

Industries that use CFCC components in their applications will realize substantial energy, environmental and financial benefits. The use of high temperature ceramic composites in a first stage turbine inner shroud and combustion liner application will significantly reduce cooling air usage leading to more efficient gas turbines. The increased efficiency will reduce energy consumption and significantly reduce NOx and CO_2 emissions harmful to the environment. Specific benefits include:

- operating gas turbines at high temperatures
- increased gas turbine efficiency
- lower gas turbine emissions
- reduced gas turbine operating cost

APPLICATIONS

The combination of the CFCC shroud and combustor applications offers economic, energy and environmental benefits. Application throughout the entire U.S. industrial and electric utility base represents an energy savings and environmental opportunity that is so large that, once proven, it could be adopted for all new gas turbine installations. CFCC components provide a wide range of energy saving applications for the Industries of the Future such as refining, chemicals, forest products, steel and agriculture.

CFCC COMPONENTS FOR INDUSTRIAL GAS TURBINES IMPROVE EFFICIENCY AND LOWER EMISSIONS

The U.S. Department of Energy's Office of Industrial Technologies (OIT) initiated the Continuous Fiber Ceramic Composite (CFCC) Program in 1992 as a collaborative effort between industry, National Laboratories, universities and government.

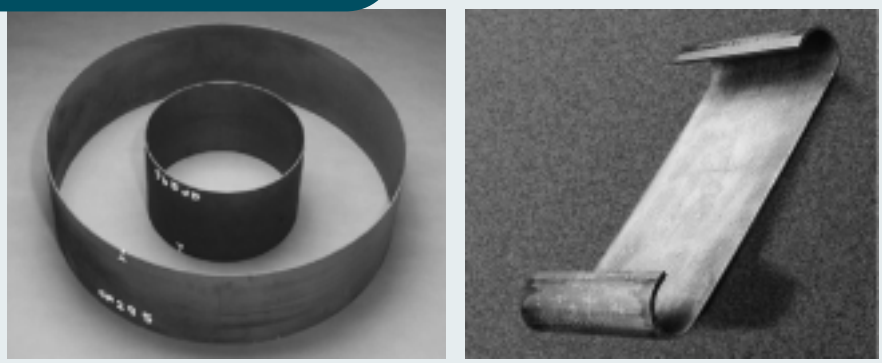
The CFCC Program is working with industry and the Oak Ridge National Laboratory to develop and test CFCC materials for applications in gas turbines. CFCC combustor liners, shrouds, and interstage seals improve efficiency and environmental performance in industrial gas turbines. These components will allow higher temperature operation in the turbine, increased efficiency of the power generation unit, and lower emissions.

General Electric Company is developing a melt infiltration ceramic composite material consisting of continuous silicon carbide fibers in a matrix of silicon carbide and silicon. The material's lack of porosity gives the composite good oxidation resistance and thermal and mechanical properties. This CFCC material is well suited for land-based gas turbine combustor liners and shrouds.

AlliedSignal Composites, Incorporated is fabricating silicon carbide matrix CFCC components using a chemical vapor infiltration (CVI) process. They are also fabricating silicon carbide and alumina fiber-reinforced alumina matrix composites using the directed metal oxidation process (DIMOX™). CFCC components fabricated by these processes include gas turbine combustor liners and shrouds.

Dow Corning Corporation has developed a versatile polymer impregnation and pyrolysis (PIP) process to fabricate complex-shaped ceramic composites. CFCC components fabricated by this process include gas turbine combustor liners, seals, and tipshoes.

GAS TURBINE COMPONENTS



CFCC gas turbine combustor liner (left - sized either at 30 or 13 inch diameter) and shroud (right - 5 inches long) help increase turbine efficiency.

Project Description

Goal: The goals of this project are to: 1) develop and optimize various CFCC material systems for application in industrial gas turbines; and 2) demonstrate processing methods suitable for cost effective manufacturing.

This project will develop effective screening tests to characterize the material performance in gas turbine environments, examine and understand material degradation mechanisms, and improve material life. Long term testing of representative components in real and simulated environments, and post-test evaluations will be performed to validate that CFCC materials are stable for long periods (>8,000 hours) in a gas turbine combustion environment.

As exhibited by this project, the CFCC Program is addressing the critical need for advanced materials that are lighter, stronger, and more corrosion-resistant than metals. The Program strives to advance processing methods for reliable and cost-effective ceramic composite materials to a point at which industry assumes the full risk of development and commercialization.

Progress and Milestones

General Electric Corporation

- Redesigned the shroud component to reduce in-service component stresses and to simplify fabrication techniques.
- Fabricated a shroud combustion test rig which allows testing of representative CFCC turbine components under full turbine temperature and pressure operating conditions. Performed over 300 hours of testing and 500 flame-off cycles on four different CFCC materials.
- Developed low cost furnace cycle test for long-term testing of CFCC samples in gas turbine environments. Over 2,000 hours of testing has been performed on four different CFCC materials.

AlliedSignal Composites, Incorporated

- Developed processing methods to produce full-sized CFCC combustor liners which survived 1,000 hours and 2,400 hours commercial engine operation in a Solar Turbines "Centaur" engine. 8,000 hour tests are planned.
- Performed Manufacturing feasibility and cost study of combustor liners. Verified fabrication techniques and identified elements for improvement.

Dow Corning Corporation

- Demonstrated the ability to fabricate prototype rim seal and turbine tipshoe with a 0.4" wall thickness for power generating gas turbines.
- Elevated temperature abradability of CFCC materials for seal applications was demonstrated by rub testing carried out by Solar Turbines, Incorporated.

Oak Ridge National Laboratory

- Developed and verified the operation of a high-temperature, high-pressure exposure facility for evaluating the long-term stability of CFCCs which are candidates for components in industrial gas turbines. To date, eight 500 hour and three 100 hour exposure tests have been conducted.
- Completed extensive microstructural characterization of samples exposed in the high-temperature, high-pressure exposure facility. By comparing the microstructural data with those generated for actual in-service CFCC combustors, the validity of the exposure facility in simulating combustor liner damage was confirmed.

Project Partners

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Oak Ridge National Laboratory
Oak Ridge, TN

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